Journal of Clinical Gerontology & Geriatrics 2 (2011) 109–115

Contents lists available at SciVerse ScienceDirect

Journal of Clinical Gerontology & Geriatrics

journal homepage: www.e-jcgg.com

Original article

Balance concerns in the elderly: Real or imaginary?

Xiao Jing Yang, MBBS, MWomens'Hlth, MHlthSc [a,b,*], Keith Hill, PhD, GradDipPhysio, BAppSc Physio [a,c], Kirsten Moore, MA Hons [a], Sue Williams, BSc, BAppSc, MPhysio [a], Leslie Dowson, BSc, MEthics [a], Karen Borschmann, BPhysio [a], Shyamali C. Dharmage, MBBS, MSC, MD, PhD [b]

[a] *Preventive and Public Health Division, National Ageing Research Institute, Parkville, Victoria 3052, Australia*
[b] *Center for Molecular, Environmental, Genetic and Analytic Epidemiology, School of Population Health, University of Melbourne, Carlton, Victoria 3053, Australia*
[c] *Musculoskeletal Research Centre and School of Physiotherapy, Faculty of Health Sciences, La Trobe University/Northern Health, Bundoora, Victoria 3086, Australia*

ARTICLE INFO

Article history:
Received 16 May 2011
Received in revised form
21 October 2011
Accepted 24 October 2011

Keywords:
Aged
Early diagnosis
Elderly
Postural balance

ABSTRACT

Background/Purpose: Older people commonly have concerns about their balance and mobility. This study aimed to identify the prevalence of mild balance dysfunction in community-dwelling older people with self-expressed concerns about balance and to determine factors associated with the presence of mild balance dysfunction.
Methods: This was a cross-sectional study in Melbourne, Australia. Participants underwent a comprehensive assessment using clinical and force platform measures to detect mild levels of balance dysfunction. The independent association between potential factors and the presence of mild balance dysfunction was examined by multiple logistic regression while adjusting for confounding effects.
Results: A total of 225 participants were recruited. Using a classification algorithm following assessment, 165 participants [73%, 95% confidence interval (CI): 68%–79%] were classified as having mild balance dysfunction. Some of the clinical measures such as the Step Test appeared to be able to discriminate between those with mild balance dysfunction and those without. Factors that were associated with mild balance impairment include: walking velocity [odds ratio (OR) = 0.817, 95% CI: 0.694–0.963); self-report physical activity level (OR = 0.798, 95% CI: 0.649–0.981); and self-reported balance concerns during walking (OR = 2.207, 95% CI: 1.020–4.785).
Conclusion: The majority of participants who reported balance concerns had measurable mild balance dysfunction. Early risk identification should target those have lower physical activity level, have slower walking velocity, and express concerns about their balance during walking. Further research should investigate the utility of the simple clinical measures in isolation to classify risk of mild balance dysfunction. Health professionals should refer older people who report balance-related concerns to appropriate investigators and interventionists.

1. Introduction

Balance related complaints such as "feeling unsteady" or "balance not as good as it used to be" are common among community-dwelling older people. Many older people tend to ascribe this to be just related to their age, and consider nothing can be done about it, so they do not seek medical review. As a consequence of their balance-related concerns, older people's falls-efficacy and self-efficacy is likely to decrease, and they may subsequently start to curtail their activities.[1] Curtailment of activity has shown to have progressive negative impact on older people, predicting decline in physical function over time.[2]

Older people's balance-related concerns may indicate age-related or disease-related declines in the balance system.[3] Some of these people will have an identifiable balance problem if assessed with a suitable assessment battery, while others may be identified as being within normative limits, and may be considered the "worried well." From a health promotion and prevention perspective, there is a need to determine if early or mild signs of balance dysfunction in community dwelling older people can be identified, rather than waiting for balance and related problems to develop to a more advanced and recognizable level. Successful identification of mild balance dysfunction may then be a basis for

* Corresponding author. National Ageing Research Institute, Post Office Box 2127, Royal Melbourne Hospital, Victoria 3050, Australia.
E-mail address: jing@nari.unimelb.edu.au (X.J. Yang).

2210-8335
doi:10.1016/j.jcgg.2011.11.004

early and targeted interventions to improve balance performance and reduce future falls risk.

Several studies have shown that older people's self-reporting of their own abilities is associated with their actual physical performance. For example, self-rated functional capacity is related to the measured function level,[4] and self-reported walking ability predicts older people's mobility performance.[5] A recent study found that older people's self-reported impaired balance was associated with increased risk of an injurious fall over the subsequent year.[6] These research findings imply that older people's balance related concerns might be an indicator of actual balance dysfunction at mild levels before it becomes clinically obvious. There is a need to extend this work to determine whether older people's perceptions of concerns related to their balance is an indicator of a measurable decline in balance performance outside of that which would be expected due to age alone.

Most studies investigating balance impairment in older people have incorporated a limited range of balance assessment tools only,[7,8] most commonly using simple clinical measures. Balance is multidimensional and different measures have been designed to assess different aspects of balance or a person's balance ability under different conditions.[9] These included measures of static and dynamic standing balance, utilizing tasks commonly involved in falls, such as stepping, reaching or leaning, and turning. In addition, measures sensitive to mild dysfunction are likely to be required in detecting older people's mild balance dysfunction, and there is evidence that some simple clinical measures suffer from ceiling effects.[10] A computerized force platform balance measures provide quantitative information about stability and weight transference.[11] Previous studies have demonstrated that these objective measurements are sensitive to age-related differences in postural sway and impairment in dynamic balance performance,[12] and, therefore, may be useful in identifying mild levels of balance dysfunction.

This paper aimed to determine the prevalence of mild balance dysfunction and to identify associated risk factors in a sample of community ambulant older people who were still active, but reported concerns about balance and mobility. A comprehensive balance assessment incorporating clinical and computerized balance measures was utilized in screening for mild balance dysfunction in this patient population.

2. Methods

2.1. Study sample

Two hundred and twenty five participants were recruited from metropolitan Melbourne by advertising in newspapers and newsletters, as well as by talking to community groups of older people. Data collection started in February 2006 and was completed in September 2007. Inclusion criteria were selected to provide a relatively well and community ambulant sample without high level or obvious falls risk to achieve the study aims. Inclusion criteria were being aged 65 years and over, living in the community, being community ambulant (defined as being able to walk away from home at least three times per week), requiring no walking aid or using a single point stick only, experiencing no more than one fall in the past 12 months, and having concerns about balance or mobility. A brief telephone-screening interview was administered to ensure that participants met all inclusion criteria based on self-reporting. Presence of balance concerns as an inclusion criterion was based on self-reporting to the question "Are you concerned about your balance?" Participants who responded yes were asked to describe which of a range of situations caused their balance concerns.

2.2. Comparative samples

Data are reported from two other studies to put the performance scores of the current study sample into context. Data for healthy older people have been derived from a study reporting similar clinical measures on a well-screened sample,[13] which ($n = 96$) had an average of 74 years; all were community dwelling healthy older women, did not use any gait aid for outdoors walking, had no history of falls in the preceding 12 months, and were screened as free of balance dysfunction. Data from a high falls risk group (older people presenting to a specialist at Falls Clinics in Victoria, Australia) are also reported.[14] This sample ($n = 454$) had an average age of 78 years, an average of 7.6 (SD = 2.8) falls risk factors at initial Falls Clinic assessment, 73% were women, and 63% had two or more falls in the preceding 6 months.

2.3. Data collection

A project manual was developed recording standardized study procedures and assessment tools. The research team involved in assessing participants was trained by an experienced neurologic/gerontologic physiotherapist, to ensure consistency in data collection.

Eligible participants attended the balance and gait laboratory for a comprehensive balance assessment. The assessment included a series of clinical and laboratory measures of balance and mobility.

Clinical measures of balance, mobility and strength included:

1. Functional reach (FR) test[7]: The maximal distance (cm) that a participant could reach forward horizontally was measured while maintaining balance with feet 10 cm apart.
2. Step Test (ST)[15]: The number of times a participant could step one foot fully on and then off a 7.5-cm block in 15 seconds as quickly as possible was recorded. Scores were derived for both the right foot stepping and the left foot stepping. The lower of the two scores was reported.
3. Timed Sit-to-Stand (five times)[8]: The participant stood up and sat down as quickly as possible from a standard chair (47-cm high) five times in a row, with their arms folded across their chest.
4. Lower limb muscle strength[16]: A Nicholas Manual Muscle Tester (hand held dynamometer) was used to measure three groups of leg muscles bilaterally: hip abductors, quadriceps, and ankle dorsiflexors. Lower limb muscle weakness generally, and specifically in quadriceps and ankle dorsiflexors, has been shown to be associated with increased falls risk.[17] Three trials were conducted for each muscle group for each leg. The standardized strength measure for a muscle group was derived by dividing the average of results of trial 2 and 3 by the participant's weight. The lower score between the right and left side was reported for the three groups of muscles.
5. Walking velocity (m/minute): The participant was asked to walk at their "comfortable walking pace" along a 10-m walkway. Gait in the central 6 m of the walkway was timed. The 2 m before and after the central 6 m were to allow for acceleration and deceleration phases of gait to be outside of the measurement time. Participants used their usual indoors gait aid.

The NeuroCom Balance Master [NeuroCom International Inc., Clackamas, OR, USA (long plate)] was also used to assess balance during six functional tasks. Reliability of these tests has been reported previously.[18] Test procedures have been described by Vrantsidis and colleagues.[19]

1. Modified Clinical Test of Sensory Interaction on Balance (mCTSIB): quantified postural sway velocity with the

participant standing still on the force plate under four different sensory conditions (eyes open/eyes closed on a firm surface and then eyes open/eyes closed on a foam surface). A composite score of Centre of Gravity (COG) Sway Velocity (degree/sec) was reported across the four tests.

2. Limits of Stability (LOS): measured participants' ability to voluntarily control weight shift in eight directions and to hold as close to a target set at 100% limit of stability in each direction. A composite measure of Reaction Time (sec), Movement Velocity (degree/sec) and Maximum Excursion (% of LOS) combining performance in the eight directions was reported.
3. Rhythmic Weight Shift (RWS): examined participants' ability to move the Centre of Gravity (COG) rhythmically front/back and to modify the timing of the COG movement so as to match the speed of a moving cue at three different speeds. A composite score of On-Axis Velocity (deg/sec) and Direction Control (%) across the three speeds was reported.
4. Walk Across (WA): quantified several characteristics of gait as the participant walked across the force plate. Step Width (cm) was reported.
5. Step Quick Turn (SQT): quantified the velocity and stability of walking and turning. Three trials turning to the right and three trials turning to the left were assessed. A combined score for the three trials of the Turn Time (sec) and Turn Sway (degree/sec) was used, and the higher (worse) score between turning to the right and turning to the left was reported for the two measures.
6. Stability during Sit to Stand (STS): examined participants' ability to stand up from a 41 cm high block without upper extremity assistance and the stability during sit to stand. A composite score of three trials for Rising Index (%) (the amount of force exerted by the legs during the rising phrase, expressed as percentage of body weight) and COG Sway Velocity (degree/sec) (the speed of COG movement during the rise to stand and for the first five seconds following the rise) were reported.

Other information collected included demographic data, detailed medical history, medication use, and information about falls in the past 12 months (retrospective recall). The Human Activity Profile (HAP) was utilized to measure participants' activity level[20] and the Adjusted Activity Score (AAS) was reported. The HAP questionnaire consists of 94 activities listed in order of increasing energy expenditure. For each item the participant was asked to indicate whether they were "still doing the activity," "have stopped doing the activity," or "never did the activity." The Maximal Activity Score (MAS) is the highest numbered item rated as "still doing." The AAS is calculated by subtracting the number of lower numbered activities (than the MAS) that were rated as "stopped doing" from the MAS score. The Assessment of Quality of Life (AQoL) was used to measure health related quality of life.[21] The AQoL comprises five domains and 15 questions, and each of the 15 questions has four answer options. The participant was instructed to choose the alternative that best described their health status over the past week. Fear of falling was measured using the Modified Falls Efficacy Scale (MFES),[22] which consists of 14 activities, each of which is rated by the participant on a 0 to 10 scale. On the scale, 0 indicated no confidence that the activity could be performed without overbalancing, and 10 indicated complete confidence in performing the activity without overbalancing or falling. The average score of rated items was reported as MFES score.

2.4. *Classification of mild balance dysfunction*

To date, there is no accepted classification or agreed balance assessment items or cut-off scores to determine whether an older person has mild balance dysfunction. Balance is multidimensional and studies suggest that a combination of measures is required to obtain a comprehensive profile of balance ability.[6] For the purposes of this study, the following criteria were used in classifying mild balance dysfunction: (a) participants who had any abnormal scores on clinical measures (defined as worse than one standard deviation from the mean score published for healthy older people.[7,8,15] Normative performance on any physical task incorporates a moderate degree of variability around the mean. Many studies have cited a level of one standard deviation from the mean performance level to be reflective of normative performance.[23] We have used this same criterion to define normative range, or those with mild balance dysfunction. For the clinical measures used for this purpose, cut-off scores to indicate mild balance dysfunction were: Functional reach <26 cm (7), Step Test <13 steps/15 seconds,[15] Times Sit-to-Stand (five times) >17.9 seconds[8]; and/or (b) participants who had more than three abnormal scores on the NeuroCom measures. Age and sex normative limits for these measures are available from a data set provided with the NeuroCom system. From the six tests used from the NeuroCom Balance Master (see above) there were 46 individual scores derived (excluding composite scores). We have accepted a small number (three or less) of these scores being outside of normative limits as being indicative of normative balance performance, while four or more of the 46 measures being outside of normative limits was considered to indicate mild balance dysfunction.

2.5. *Statistical analysis*

Analyses were undertaken using the statistical software package SPSS Graduate Pack 15.0 for Windows (Chicago, Illinois, USA). The percentage of older people who were classified as having balance performance outside of normal limits and associated 95% CIs were reported. T-tests were used to compare performance on each individual balance task between the group classified with mild balance dysfunction, and the group with balance within normal limits.

Univariate and multivariate logistic regression procedures were employed to assess relationships between potential risk factors and probable mild balance dysfunction. For the univariate analysis, 26 factors were analyzed, including age, gender, medical conditions, medication use, balance-related concerns, walking, and activity level. Where variables were strongly associated, indicating multicollinearity, only one of the pair of variables was selected for inclusion in the regression analysis. Participants who were classified as having mild balance dysfunction and those who were classified as free of balance dysfunction were compared. Variables with a p value <0.1 in the univariate analysis were included in a multivariate logistic regression model. ORs and 95% CIs were calculated.

3. Results

Two hundred and twenty five participants were recruited, with a mean age 79.7 years (95% CI: 78.9–80.5 years). Fifty-six percent (126 participants) were men. One hundred and twenty one (53.8%) participants were married. The majority of participants (208, 92.4%) were living at home with no career.

According to the classification of balance ability described in the Method, 165 participants (73.3%, 95% CI: 68%–79%) were classified as having mild balance dysfunction.

Table 1 compares participants' performance on outcome measures between those categorized as having balance within normal limits, and those who were classified as having mild balance dysfunction. On most of the measures the group with mild balance dysfunction scored significantly worse than the group who were classified as having normal balance performance.

Table 1
Balance performance of the mild balance dysfunction (MBD) group and normal balance (normal) group

Outcome	MBD group *(n = 165)*	Normal group *(n = 60)*	*p* value	Scores for healthy participants[‡]
Laboratory measures				
mCTSIB*—mean COG sway velocity, composite (deg/sec)	1.72 (1.63–1.80)	1.09 (0.97–1.21)	<0.001[†]	
LOS*—reaction time, composite (sec)	0.93 (0.89–0.97)	0.81 (0.76–0.86)	0.001[†]	
LOS—movement velocity, composite (deg/sec)	2.95 (2.77–3.13)	3.73 (3.42–4.05)	<0.001[†]	
LOS—maximum excursions, composite (% LOS)	71.96 (69.71–74.22)	85.47 (83.06–87.89)	<0.001[†]	
RWS—on-axis velocity (front/back), composite (deg/sec)	2.49 (2.37–2.60)	3.23 (3.11–3.34)	<0.001[†]	
RWS—direction control (front/back), composite (%)	70.97 (69.28–72.66)	79.55 (77.93–81.16)	<0.001[†]	
WA*—step width (cm)	17.29 (16.63–17.94)	15.28 (14.36–16.20)	0.002[†]	
SQT*—turn time, worst (sec)	1.65 (1.53–1.76)	1.18 (1.06–1.31)	<0.001[†]	
SQT*—turn sway, worst (deg)	35.24 (27.30–31.72)	29.51 (27.30–31.72)	<0.001[†]	
STS—rising index (%)	17.64 (16.20–19.07)	19.18 (16.19–22.18)	0.297	
STS*—COG sway velocity (deg/sec)	4.78 (4.56–4.99)	4.34 (4.04–4.63)	0.021[†]	
Clinical measures				
Functional reach (cm)	26.4 (25.6–27.3)	32.1 (31.1–33.1)	<0.001[†]	30.7 (29.9–31.5)
Step test, worst	14.0 (13.4–14.5)	18.1 (17.3–18.9)	<0.001[†]	16.1 (15.5–16.7)
Timed STS*, five times (sec)	10.9 (10.3–11.6)	8.8 (8.3–9.2)	<0.001[†]	
Quadriceps strength, (kg/body weight-kg), worst	0.20 (0.19–0.21)	0.22 (0.20–0.24)	0.023[†]	0.13 (0.12–0.14)
Hip abductor strength (kg/body weight-kg), worst	0.15 (0.14–0.16)	0.16 (0.15–0.18)	0.058	0.13 (0.12–0.14)
Dorsiflexors strength (kg/body weight-kg), worst	0.15 (0.14–0.15)	0.16 (0.16–0.17)	0.002[†]	0.14 (0.13–0.15)
Walking velocity (m/min)	62.6 (60.4–64.8)	74.4 (71.4–77.5)	<0.001[†]	69.9 (68.6–71.2)

Values are means and 95% CI.
[†]Significant difference ($p < 0.05$) from two-sample t test with equal variances.
CI = confidence interval; COG = center of gravity; LOS = limits of stability; mCTSIB = modified clinical test of sensory interaction on balance; RWS = rhythmic weight shift; SQT = step quick turn; STS = sit to stand WA = walk across.
* Smaller score represents better performance.
[‡] From Hill K, Schwarz J, Flicker L, Carroll S. Falls among healthy, community-dwelling, older women: a prospective study of frequency, circumstances, consequences and prediction accuracy. *Aust N Z J Public Health* 1999;**23**:41–8. Sample of healthy women, mean age 74.1 years, muscle strength was reported in the original paper as force (g)/body weight (kg).

Table 2 presents the commonly reported circumstances when participants felt unsteady, or had to be cautious, based on their self-report. Participants could report more than one concern. The proportion of participants reporting each balance-related concern varied between those classified as having mild balance dysfunction, and those classified as within normal limits. A significantly greater proportion of those in the mild balance dysfunction group reported balance related concerns during walking, and concerns in accessing the community ($p < 0.05$).

Fig. 1 shows a comparison on the Step Test (worst leg), one of the clinical tests between participants in the current study ($n = 225$), a sample of healthy older people ($n = 96$) living in the community[13] and a sample of patients ($n = 454$) who attended a Falls and Balance Clinic.[14] Participants recruited for the current study performed just below the 95% CI range for the healthy group, while their performance was considerably better than the falls and balance clinic sample. A similar pattern was observed for other measures (Functional Reach, Human Activity Profile and Modified Falls Efficacy Scale) where comparative data were available.

Table 3 (left half of the table) presents the univariate odds ratios for the associations between each potential factor and the presence of mild balance dysfunction, adjusted for age and sex. Factors identified with a *p* value <0.1 were: using a walking stick; self-reported balance concerns during walking; history of hypertension; number of medical conditions; number of prescribed medications; taking antihypertensive medications; walking velocity and physical activity level (AAS score for Human Activity Profile).

Three pairs of factors were identified as likely to be strongly associated (history of hypertension and taking hypertensive medications; using walking aid and walking velocity; and number of prescribed medications and number of chronic health conditions). In order to minimize risk of collinearity, only one variable from each of these pairs was selected to put into the final model (walking velocity, number of chronic health conditions, and history of hypertension were included in the multiple logistic regression model). Results of the multivariate model (right half of Table 3) showed that walking velocity, physical activity level (AAS score for Human Activity Profile) and self-reported balance concerns during walking remained significantly associated with the presence of mild balance dysfunction, after adjusting for the confounding effect of other variables considered in the model.

4. Discussion

Many older people have concerns about their balance performance, even those who are community dwelling and functionally

Table 2
Commonly reported activities that participants had balance-related concerns*

	All participants *(n = 225)*	Normal group *(n = 60)*	MBD group *(n = 165)*	*p* value
During walking	156 (69%)	33 (55%)	123 (75%)	<0.01[†]
After first standing (morning)	48 (21%)	13 (22%)	35 (21%)	0.828
Getting dressed or showering	58 (26%)	13 (22%)	45 (27%)	0.183
Gardening, outdoor activities	20 (9%)	7 (12%)	13 (8%)	0.482
Using public transport	18 (8%)	3 (5%)	15 (9%)	0.219
Sports, physical activities	16 (7%)	5 (8%)	11 (7%)	0.828
Accessing the community	17 (8%)	1 (2%)	16 (10%)	0.021[†]

Values are n (%).
[†]Significant difference between groups ($p < 0.05$) from two-sample test of proportion.
MBD = mild balance dysfunction.
* Participants could report more than one concern.

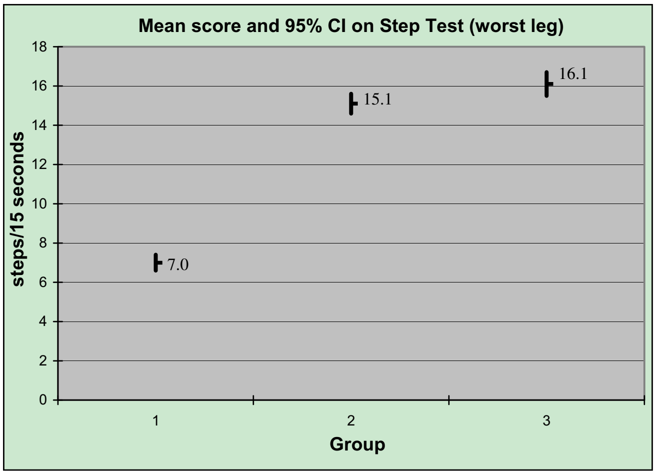

Fig. 1. Comparison of mean score and 95% CI on step test (worse leg) between three samples of older people. Group 1: Falls and balance clinic patients (*n* = *454*), mean = 7.0 steps/15 seconds (95% CI: 6.6–7.4 steps/15 seconds). From Hill K, Moore KJ, Dorevitch MI, Day LM. Effectiveness of falls clinics: an evaluation of outcomes and client adherence to recommended interventions. *J Am Geriatr Soc* 2008;**56**:600–8. Group 2: Current study participants (*n* = *225*), mean = 15.1 steps/15 seconds (95% CI: 14.6–15.6 steps/15 seconds). Group 3: Healthy older people sample (*n* = *96*), mean = 16.1 steps/15 seconds (95% CI: 15.5–16.7 steps/seconds). CI = confidence interval. From Hill K, Schwarz J, Flicker L, Carroll S. Falls among healthy, community-dwelling, older women: a prospective study of frequency, circumstances, consequences and prediction accuracy. *Aust N Z J Public Health* 1999;**23**:41–8.

independent. In one study, approximately 20% of older people living in the community aged 70–79 years, and more than 30% of people aged 80 years or older had self-reported balance impairment.[24] Often older people, their families and some health professionals consider such concerns as "a normal part of ageing" or "imaginary" unless falls happen frequently or an injurious fall occurs. In this study, almost three-quarters of older people expressing concerns about their balance, but who remained community active, did have measurable balance dysfunction. This finding highlights that older people's balance related concerns are often not just imaginary. Instead, their reports of concerns about their balance should be considered as an important indicator of potential loss of balance ability, and a trigger of the need for a detailed balance assessment. Identification of balance dysfunction at mild levels of impairment may be used as a trigger to implement preventive strategies such as balance exercise programs. However, we are unable to determine the true prevalence of the incidence of mild balance dysfunction among those expressing some concerns about their balance, as this was a volunteer, and not a representative sample.

Exercise programs have been shown to improve balance performance, muscle strength and reduce falls risk in older people,[25] and have been shown to be effective in reducing falls across the falls risk spectrum.[26] Balance related exercise has also been shown to improve confidence and falls efficacy in older people with increased falls risk.[27] From a health promotion point of view, detection of mild balance impairment enables earlier implementation of interventions, with greater capacity in improving older people's balance performance, rather than waiting until higher levels of falls risk or balance impairment develop.

At present, there is no gold standard available in classifying "normal balance performance" or "balance dysfunction" in older people, especially at mild levels. In this study, the classification of mild balance problems was based on a review of the suite of clinical and laboratory measures, and *a priori* determination of cut-off scores to indicate mild balance dysfunction. According to Table 1, on most individual measures, including the simple clinical

Table 3
Analysis of factors associated with mild balance dysfunction (MBD) in univariate and multivariate analysis

Factor	Univariate analysis				Multivariate analysis‡		
	MBD group, *N* = *165*	Normal group, *N* = *60*	Odds ratios (95% CI)	*p* value	Odds ratio	95% CI for Odds ratio	*p* value
Age (yrs)	80.6 (79.7–81.5)	76.9 (75.5–78.3)	1.10 (1.05–1.16)	0.036†	1.03	0.97–1.10	0.293
Being female	73 (44%)	26 (43 %)	1.40 (0.74–2.66)	0.304	0.92	0.43–1.97	0.826
Without a spouse	86 (52%)	18 (30%)	0.53 (0.24–1.51)	0.109			
Had home help	53 (32%)	8 (13%)	2.15 (0.91–5.05)	0.112			
Being a veteran	121 (73%)	35 (58%)	1.21 (0.55–2.66)	0.645			
Use walking stick	39 (24%)	3 (5%)	4.80 (1.40–16.47)	0.013†			
A fall in past year	64 (39%)	17 (28%)	1.45 (0.75–2.82)	0.274			
Concern about balance during walking	123 (75%)	33 (55%)	2.60 (1.32–5.13)	0.006†	2.21	1.02–4.79	0.044†
Concern about balance after first standing (morning)	35 (21%)	13 (22%)	0.95 (0.45–2.02)	0.893			
Visual problems	55 (33%)	14 (23%)	1.45 (0.72–2.92)	0.295			
Hypertension	98 (59%)	25 (42%)	2.04 (1.10–3.80)	0.024†	1.86	0.823–4.18	0.134
Arthritis in lower limbs	96 (58%)	32 (53%)	1.06 (0.57–1.96)	1.862			
Joint replacement	28 (17%)	8 (13%)	1.16 (0.49–2.77)	0.740			
Cardiac conditions	55 (33%)	16 (27%)	1.13 (0.57–2.67)	0.960			
Diabetes	16 (10%)	6 (10%)	0.97 (0.36–2.67)	0.960			
History of stroke	18 (11%)	1 (2%)	6.86 (0.87–35.6)	0.123			
Back pain	71 (43%)	32 (53%)	0.68 (0.37–1.24)	0.208			
Osteoporosis	26 (16)%	6 (10%)	1.67 (0.64–4.39)	0.284			
Number of medical conditions	4.1 (3.8–4.4)	3.6 (3.1–4.1)	1.17 (0.98–1.38)	0.079	1.01	0.81–1.25	0.954
Number of prescribed medications	4.1 (3.7–4.6)	3.2 (2.6–3.8)	1.15 (1.01–1.31)	0.034†			
Psychotropic medications	19 (12%)	8 (13%)	0.82 (0.33–2.02)	0.667			
Cardiac medications	28 (17%)	5 (8%)	1.81 (0.65–5.05)	0.259			
Antihypertensive medications	93 (56%)	23 (38%)	2.02 (1.08–3.78)	0.029†			
Walking velocity* (m/min)	62.7 (60.5–64.9)	74.8 (71.8–77.9)	0.94 (0.91–0.97)	0.012†	0.82	0.69-0.96	0.016†
Physical activity level* (AAS-HAP)	61.5 (59.7–63.4)	69.8 (67.3–32.4)	0.95 (0.91–0.98)	0.001†	0.80	0.65–0.98	0.032†
Fear of falling (MFES)	9.16 (8.97–9.35)	9.52 (9.18–9.87)	0.98 (0.89–1.04)	0.181			

Values are n (%) or means (95% CI).
†$p < 0.05$.
‡Variables that with $p > 0.1$ in univariate regression analysis were not included in the multivariate model, except being female for adjusting purpose.
AAS = adjusted activity score; CI = confidence interval; HAP = human activity profile; MBD = mild balance dysfunction; MFES = modified falls efficacy scale.
* Odds ratio and associated 95% CI was calculated for every five units because this would be clinically meaningful.

measures, participants who were classified as having normal balance scored considerably better than those who were classified as having mild balance dysfunction, and most differences were statistically significant. This indicates that the combined criteria used in this study were able to distinguish the two groups of older people with mild differences in level of balance ability across a broad range of balance assessment domains. Importantly, this study has also highlighted that mild balance impairment could be measured in this sample of community-ambulant older people, who remained active but expressed concerns about their balance. Fig. 1 demonstrated the study participants' balance performance in comparison to two other samples on one of the clinical measures, the Step Test. As expected, this sample's mean score and 95% CI was well above the Falls and Balance Clinic patients (high falls risk sample), however, compared to the sample of healthy older people, participants in the current study scored slightly but significantly worse. This suggests that the balance performance of older people with self-reported balance concerns might have started deteriorating while their symptoms are not yet clinically obvious. It also suggests that simple clinical measures such as the Step Test used in this study, or other tests aimed at discriminating mild levels of balance dysfunction such as the Four Square Step Test,[28] or the Multiple Tasks Test[29] might be sufficient for discriminating mild balance dysfunction, rather than requiring the force platform assessments that also formed part of the current study. Further research is required to determine the usefulness of a single or combination of simple clinical tests in screening for mild balance dysfunction in older people. This could include evaluating whether screening can be as effective without using high technology (force platform) devices that have limited feasibility and generalizability for use in routine clinical practice.

Sit to stand is an important skill needed for everyday life. Previous studies reported the timed Sit-to-Stand tests being useful in discriminating between older people with a balance disorder and those without,[8] and those with increased falls risk.[30] In our results (Table 1) participants classified as having mild balance dysfunction performed significantly worse on the Five Times Sit-to-Stand test than those classified as having normal balance performance. However, there was no significant difference between groups on the Rising Index (%) reported for the Sit-to-Stand test on the NeuroCom, although the scores for the normal balance group were on average eight percent higher than the mild balance group. This may indicate a lower sensitivity of measurement for detecting differences or changes for the Rising Index measure compared to the timed task in this sample.

All study participants reported concerns about their balance as it was one of the inclusion criteria. Table 2 listed the commonly reported circumstances when participants felt unsteady, or had to be cautious, based on their self-report. Most of these reported activities were also items in the Modified Falls Efficacy Scale. Despite all participants reporting balance related concerns, more than one third (89 participants, 39.6%) scored fully on the MFES, which indicated absence or very low level of Fear of Falling. This observation implies that balance-related concerns and Fear of Falling may be different concepts and, therefore, cannot be used interchangeably. Furthermore, balance-related concerns may to be more sensitive than Fear of Falling for the purpose of early risk identification, as older people appeared to have developed balance related concerns in doing many daily activities prior to becoming fearful of falling.

Results from the multivariate regression model showed that lower self-reported physical activity level; slower walking velocity and having self-reported balance concerns during walking were independently associated with an increased risk of having mild balance dysfunction. Previous research has also reported that slower walking velocity was associated with recurrent falling and dynamic balance impairment,[31] as well as inactivity being associated with increased falls risk.[32] Findings from the regression model suggest that being concerned about balance during walking may be a more important sign than other balance-related concerns indicating the presence of mild balance dysfunction. Health professionals should be aware of the potential association between the three identified factors and the presence of mild balance dysfunction, and to recognize older people who are at increased risk. The three identified factors may be integrated in future programs of early risk identification.

There are several limitations to this study. Data on medical history and medication use were based on self-reporting, which might have reduced the accuracy of this data compared to medical record review. Second, the classification of mild balance dysfunction used in the current study may require further investigation and refinement, for instance, to determine the cut-off scores between mild and moderate balance dysfunction. In addition, the diagnostic accuracy of the classification could not be evaluated. This was due to there being no accepted reference standard in determining the presence or absence of "mild balance dysfunction" in older people. Third, because we did not have a comparison group (such as older people without balance-related concerns) we were unable to ascertain whether the factors that were identified as being associated with the presence of mild balance dysfunction are unique to older people with balance-related concerns only. Regarding the sampling method, a set of inclusion criteria were employed aiming to exclude older people with balance impairments worse than "mild" from participating. However, there might be a possibility that a small proportion of participants were included with moderate levels of balance dysfunction while still meeting the inclusion criteria, although data in Table 1 indicates that on average, participants were performing just outside normative levels on a number of clinical measures. Caution needs to be used in interpreting the comparison of our study results with the well-screened healthy sample and the Falls Clinic sample, as this data is from three separate studies, and there are age differences (up to 6 years difference in the study samples), between the samples, and the healthy older sample consisted of only females. Balance performance has been shown to deteriorate with age (one study demonstrated a reduction in Step Test performance of approximately 0.5% per year),[33] and some studies have reported a gender difference in balance performance.[34] Finally, using a convenience sample of volunteers, the generalizability of the study results might be limited.

5. Conclusion

A high proportion of community dwelling older people reporting concerns about their balance were shown to have measurable balance impairment outside that associated with normal age related decline. Presence of reduced walking velocity, reduced physical activity level, and self-reported balance concerns, specifically related to walking, were associated with presence of mild balance dysfunction. Screening using these items might provide practitioners with a quick and simple approach to determine whether older patient's reports of concerns about their balance are real, and warrant a detailed balance assessment to determine the need for implementation of a balance-training program.

Acknowledgments

This study was funded by the Australian Department of Veterans Affairs. Ethical approval was obtained through the Department of Veterans Affairs Ethics Committee.

The research team would like to acknowledge the Australian Government Department of Veterans Affairs for providing the research funding and to thank all of the participants for volunteering.

References

1. Reed J, Stanley D, Clarke C. *Health, wellbeing and older people*. Bristol: Policy Press; 2004.
2. Deshpande N, Metter EJ, Lauretani F, Bandinelli S, Guralnik J, Ferrucci L. Activity restriction induced by fear of falling and objective and subjective measures of physical function: a prospective cohort study. *J Am Geriatr Soc* 2008;**56**:15–20.
3. Newton RA. Balance and falls among older people. *Generations* 2003;**27**:27–31.
4. Rathouz PJ, Kasper JD, Zeger SL, Ferrucci L, Bandeen-Roche K, Miglioretti DL, et al. Short-term consistency in self-reported physical functioning among elderly women - the women's health and aging study. *Am J Epidemiol* 1998;**147**:764–73.
5. Alexander NB, Guire KE, Thelen DG, Ashton-Miller JA, Schultz AB, Grunawalt JC, et al. Self-reported walking ability predicts functional mobility performance in frail older adults. *J Am Geriatr Soc* 2000;**48**:1408–13.
6. Muir SW, Berg K, Chesworth B, Speechley M. Balance impairment as a risk factor for falls in community-dwelling older adults who are high functioning: a prospective study. *Phys Ther* 2010;**90**:338–47.
7. Duncan P, Weiner K, Chandler J, Studenski S. Functional Reach: A new clinical measure of balance. *J Gerontol* 1990;**45**:M192–7.
8. Whitney SL, Wrisley DM, Marchetti GF, Gee MA, Redfern MS, Furman JM. Clinical measurement of sit-to-stand performance in people with balance disorders: validity of data for the five-times-sit-to-stand test. *Phys Ther* 2005;**85**:1034–45.
9. Huxham FE, Goldie PA, Patla AE. Theoretical considerations in balance assessment. *Aust J Physiother* 2001;**47**:89–100.
10. Vereeck L, Wuyts F, Truijen S, Van De Heyning PV. Clinical assessment of balance: normative data, and gender and age effects. *Int J Audiol* 2008;**47**:67–75.
11. Nashner LM, Peters JF. Dynamic posturography in the diagnosis and management of dizziness and balance disorders. *Neurol Clin* 1990;**8**:331–49.
12. Dickstein R, Dvir Z. Quantitative evaluation of stance balance performance in the clinic using a novel measurement device. *Physiother Can* 1993;**45**:102–8.
13. Hill K, Schwarz J, Flicker L, Carroll S. Falls among healthy, community-dwelling, older women: a prospective study of frequency, circumstances, consequences and prediction accuracy. *Aust N Z J Public Health* 1999;**23**:41–8.
14. Hill K, Moore KJ, Dorevitch MI, Day LM. Effectiveness of falls clinics: an evaluation of outcomes and client adherence to recommended interventions. *J Am Geriatr Soc* 2008;**56**:600–8.
15. Hill K, Bernhardt J, McGann AM, Maltese D, Berkovits D. A new test of dynamic standing balance for stroke patients: reliability, validity, and comparison with healthy elderly. *Physiother Can* 1996;**48**:257–62.
16. Ottenbacher KJ, Branch LG, Ray L, Gonzales VA, Peek MK, Hinman MR. The reliability of upper- and lower-extremity strength testing in a community survey of older adults. *Arch Phys Med Rehabil* 2002;**83**:1423–7.
17. Takazawa K, Arisawa K, Honda S, Shibata Y, Saito H. Lower-extremity muscle forces measured by a hand-held dynamometer and the risk of falls among day-care users in Japan: using multinomial logistic regression analysis. *Disabil Rehabil* 2003;**25**:399–404.
18. Naylor ME, Romani WA. Test-Retest Reliability of Three Dynamic Tests Obtained From Active Females Using the Neurocom Balance Master. *J Sport Rehabil* 2006;**15**:326–37.
19. Vrantsidis F, Hill KD, Moore K, Webb R, Hunt S, Dowson L. getting grounded gracefully: effectiveness and acceptability of Feldenkrais in improving balance related outcomes for older people: a randomised trial. *J Ageing Phys Act* 2009; **17**:57–76.
20. Fix A, Daughton D. *Human activity profile professional manual*. Odessa, FL: Pychological Assessment Resources Inc; 1988.
21. Hawthorne G, Richardson J, Osborne R. The Assessment of Quality of Life (AQoL) instrument: a psychometric measure of health-related quality of life. *Qual Life Res* 1999;**8**:209–24.
22. Hill K, Schwarz J, Kalogeropoulos AJ, Gibson S. Fear of falling revisited. *Arch Phys Med Rehabil* 1996;**77**:1025–9.
23. McPoil TG, Cornwall MW. Use of the longitudinal arch angle to predict dynamic foot posture in walking. *J Am Podiatr Med Assoc.* 2005;**9**:114–20.
24. Wagner H, Melhus H, Gedeborg R, Pedersen NL, Michaelsson K. Simply ask them about their balance–future fracture risk in a nationwide cohort study of twins. *Am J Epidemiol* 2008;**169**:143–9.
25. Howe TE, Rochester L, Jackson A, Banks PMH, Blair VA. Exercise for improving balance in older people. *Cochrane Database Syst Rev* 2007. 4.
26. Sherrington C, Whitney JC, Lord SR, Herbert RD, Cumming RG, Close JCT. Effective exercise for the prevention of falls-a systematic review and meta-analysis. *J Am Geriatr Soc* 2008;**56**:2234–43.
27. Zijlstra GA, van Haastregt JC, van Rossum E, van Eijk JT, Yardley L, Kempen GI. Interventions to reduce fear of falling in community-living older people: a systematic review. *J Am Geriatr Soc* 2007;**55**:603–15.
28. Dite W, Temple VA. A clinical test of stepping and change of direction to identify multiple falling older adults. *Arch Phys Med Rehabil* 2002;**83**: 1566–71.
29. Bloem BR, Valkenburg VV, Slabbekoorn M, Willemsen MD. The multiple tasks test - development and normal strategies. *Gait Posture* 2001;**14**:191–202.
30. Najafi B, Aminian K, Loew F, Blanc Y, Robert PA. Measurement of stand-sit and sit-stand transitions using a miniature gyroscope and its application in fall risk evaluation in the elderly. *IEEE Trans Biomed Eng* 2002;**49**:843–51.
31. Stel VS, Smit JH, Pluijm SMF, Lips P. Balance and mobility performance as treatable risk factors for recurrent falling in older persons. *J Clin Epidemiol* 2003;**56**:659–68.
32. Campbell AJ, Borrie MJ, Spears GF. Risk-factors for falls in a community--based prospective study of people 70 years and older. *J Gerontol* 1989;**44**: M112–7.
33. ElHaber N, Hill K, Cassano AM, Cui J, MacInnis R, Hopper J, et al. Genetic and environmental influences on variation in balance performance in female twin pairs 21-82 years old. *Am J Epidemiol* 2006;**164**:246–56.
34. Kim JW, Eom GM, Kim CS, Kim DH, Lee JH, Park BK, et al. Sex differences in the postural sway characteristics of young and elderly subjects during quiet natural standing. *Geriatr Gerontol Int* 2010;**10**:191–8.